# Department of Mathematics, UAB
# Mathematical Modeling
# MA361-OW Summer 2024

**Instructor:** Dr Ian Knowles, Room 4024, University Hall.
**Email:** iknowles@uab.edu
**Class Meeting Times:** TuTh: 12:40 – 2:40pm, HHB 221.
**Office Hours.** See me after class (we can meet in my office); you may also email to arrange for additional office or Zoom meetings.
**Textbook.** None: we use my lecture notes; download these from Canvas.
**Prerequisite Course.** Calculus I (MA125), or permission of instructor.
**Term Dates.** First day of classes: Monday June 03, 2024. Independence Day Holiday: Thursday July 04, 2024. Last day of classes: Friday August 02, 2024.

**SageMath Software.** Access to the SageMath software package is needed for this course. This package may be freely downloaded from the SageMath website `https://www.sagemath.org/` (this is a "live" URL), with available binaries for Mac and Linux, and installation via WSL for Windows, that may be obtained by clicking the download button Download 10.3 on this website. Aside from the machines located in our classroom HHB221, additional Mac computers with SageMath installed are available in the Math Learning Lab in HHB202. Free access to SageMath is also available online via the CoCalc website located at `https://cocalc.com` (also a "live" URL).

SageMath is a computer algebra system with features covering many aspects of mathematics, including calculus, statistics, numerical analysis, and algebra. Together with the web-browser-based Jupyter Notebook this software contains much of the functionality of the commercially available packages Mathematica, Maple, and Matlab and uses a similar command set to the popular programming language Python whose syntax you will naturally acquire as you use SageMath. Please note that, while you will develop the necessary programming skills during the course, no prior computer skills are assumed at the beginning of the course.

**Grading.** There will be approximately one written Homework assignment and one computer Lab assignment per week; these collectively will constitute 100% of the course grade. There are no other written examinations in this course. Your final grade is determined from your course grade according to the following table:

| Course Grade: | 88-100 | 75-87 | 62-74 | 50-61 | below 50 |
|---|---|---|---|---|---|
| Final Grade: | A | B | C | D | F |

**Lab/Homework File Submission.** For each Homework assignment you should submit a **single *.pdf file** in Canvas on or before the due time. The easiest way to produce the requisite pdf file is to write directly on the downloaded homework pdf file (obtained from the Canvas directory `Files/Assignments`) using a tablet computer (such as an iPad). Alternately, hand-written paper homework sheets can be scanned to a single pdf file using a mobile scanning app such as Adobe Scan. Please make sure that your scanned sheets are readable (in particular, not too dark) and that you have included the whole viewing area in your scan.

For each Lab you should download the appropriate *.ipynb lab file from the `Files/Computer Labs` directory, work on it inside SageMath, and then submit the completed *.ipynb file in Canvas on or before the due time.

**Class Schedule.**

| **Week** | **Tuesday** | **Thursday** |
|---|---|---|
| 06/03 – 06/07 | First Class/Lab 1 | HW1 |
| 06/10 – 06/14 | Lab 2/Lab 1 due | HW2/HW1 due |
| 06/17 – 06/21 | Lab 3/Lab 2 due | HW3/HW2 due |
| 06/24 – 06/28 | Lab 4/Lab 3 due | HW4/HW3 due |
| 07/01 – 07/05 | | July 4 Holiday |
| 07/08 – 07/12 | Lab 5/Lab 4 due | HW5/HW4 due |
| 07/15 – 07/19 | Lab 6/Lab 5 due | HW6/HW5 due |
| 07/22 – 07/26 | Lab 7/Lab6 due | HW7/HW6 due |
| 07/29 – 08/02 | Lab 7 due | Last Class/HW7 due |
| 08/05 – 08/09 | UAB Summer Final Exam Week | |

**Syllabus.** In the course we teach mathematical modeling as a tool for predicting the long-term behaviour (dynamics) of physical and biological systems. We begin with models of dynamical processes occurring in physics, chemistry, biology, ecology, physiology, and other applications in which quantities change with time. In the lab session parts of each class, we will often run prepackaged computer programs for problem-solving, visualization, plotting and simulation. Basic programming concepts like program flow control and data structures will be introduced when needed.

**Aims of the Course.** Upon successful completion of the course a student can

- describe the dynamics in practical systems and the different types of behaviors of complex systems including steady-states and oscillations, and their causes including the effects of delay, and positive and negative feedback;
- explain how the variables in each term in the differential equations arise from practical observations and assumptions;

- translate a verbal description of interacting variables into a differential equation model of a dynamical system, using the concepts of state space and tangent space;
- simulate differential equation models using Euler's method by hand and via Python or SageMath;
- understand the meaning of the terms point attractor, periodic attractor, and chaotic attractor for a dynamical system, together with their application to the study of heart arrhythmias and neuron action potentials.
- derive models of systems that exhibit bi-stability or switch-like behavior using the concept of birfurcation.

**Reference Material.** As mentioned above, there is no prescribed textbook for this course. The book *Modeling Life* by Alan Garfinkel, Jane Shevetsov, and Yina Guo, Springer International Publishing (2017) is useful as a supplementary reference if you seek more than is in my notes. Likewise, there is no text for the Lab component of the course, which we will do as an in-class/homework activity. Regular class attendance is highly recommended for this reason. For SageMath and Python, the online documentation is quite good and of course you should never hesitate to ask me if your code is not behaving properly.